MACHINE DESIGN II
MEC 3110

BY

PROF. M. NAUSHAD ALAM

MECHANICAL ENGINEERING DEPT.

A.M.U. ALIGARH

BASICS OF MACHINE DESIGN

- **Machine Design :**

  It is defined as the use of scientific principles,

  Technical informations,

  and imagination

  in the description of a machine or mechanical system,

  to perform specific functions with maximum economy and efficiency.

- Design is an innovative and highly iterative process.

- A designer uses principles of basic engineering sciences such as physics, mathematics, statics, dynamics, thermodynamics, heat

COURSE OBJECTIVES

1. Understanding the process and methods of design of machines elements.
2. Abilities of developing equations pertaining to the design of machines.
3. Knowledge of different materials and their properties for designing the components of machine elements and the ability to design new machines or modify existing machine according to the need.

COURSE OUTCOMES

After taking this course students should be able to,

1. Design and analyse different types of clutches, brakes and welded connections.
2. Select and design appropriate bearing as per the requirement.
3. Identify different types of springs and design the same as per the requirement.
4. Design and analyze geared transmission system.

SYLLABUS

Unit-I

Welded Joints: Types of Welded connections, Design of Simple and eccentrically loaded welded connections. Clutches & Brakes: Plate, Cone and Centrifugal Clutches, Classification and Design of Brakes.

Unit-II

Bearings & Lubrication: Laws of friction, Lubrication, Hydrodynamic and Hydrostatic bearings, Ball and Roller bearings, Method of load estimation and Selection of bearings.

Unit-III

Springs: Design of helical springs, design of torsion and leaf springs, elementary idea of rubber springs.

Unit-IV

BOOKS

1. **Joseph E. Shigley;** Mechanical Engineering Design, McGraw Hill.
2. **V. B. Bhandari;** Design of Machine Elements, Tata McGraw-Hill Education
3. **M.F. Spott;** Design of Machine Element, Prentice Hall.
4. **Design Data Handbook** for Mechanical Engineers, K. Mahadevan and K. Balaveera Reddy, CBS Pub.
5. **Standard Handbook of Machine Design,** Joseph E Shigley, and Charles R. Mischke, McGraw-Hill Pub.

BEARINGS

- Bearings are machine elements which are used to support a rotating member viz., a shaft.
- They transmit the load from a rotating member to a stationary member known as frame or housing.
- They allow relative motion between two members in one or two directions with minimum friction, and also prevent the motion in the direction of the applied load.
- Bearings support a shaft or an axle and holds them in correct positions.

Classification of Bearings

- According to direction of force;
    1. Radial Bearing
    2. Thrust Bearing

- According to type of friction or contact :
    1. Sliding Contact(Journal)
    2. Rolling Contact(Antifriction)

Advantages of Sliding Contact Bearings

- Sliding contact bearings have certain advantages over the rolling contact bearings. These are:

1. Design of the bearing and housing is simple.
2. Occupy less radial space and are more compact.
3. Less expensive
4. Design of the shaft is simple.
5. Silent operation.
6. Good shock load capacity.

SLIDING CONTACT BEARINGS

- The sliding contact bearings having surface contact and are coming under lower kinematic pair.

- Based on the type of contact between the rotating and the stationary members, Sliding contact bearings may be broadly classified into following two categories:

    1. Sliding Contact(Journal)
       Surface of the shaft slides over the surface of bush

    2. Rolling Contact(Antifriction)

Applications of Sliding Contact Bearings

- Crankshaft bearings in petrol and diesel engines
- Centrifugal pumps
- Large size electric motors
- Steam and gas Turbines,concrete mixture, Rope conveyor and marine installations
- Rolling contact
- Automobile front and rear axles, machine tool spindles, Gear boxes

Disadvantages of Sliding Contact Bearings

1. Frictional power loss is more.
2. Require good attention to lubrication.
3. Normally designed to carry radial load or axial load only.

Classification of Sliding Contact Bearings

- Classified in three ways.

1. Based on type of load carried
2. Based on type of lubrication
3. Based on lubrication mechanism

1. Classification based on Type of load

- Based on the type of load carried, sliding contact bearings may be classified into the following categories:
  a. Radial bearings
  b. Thrust bearings or axial bearings

2. Classification based on Type of Lubrication

- **Lubrication**

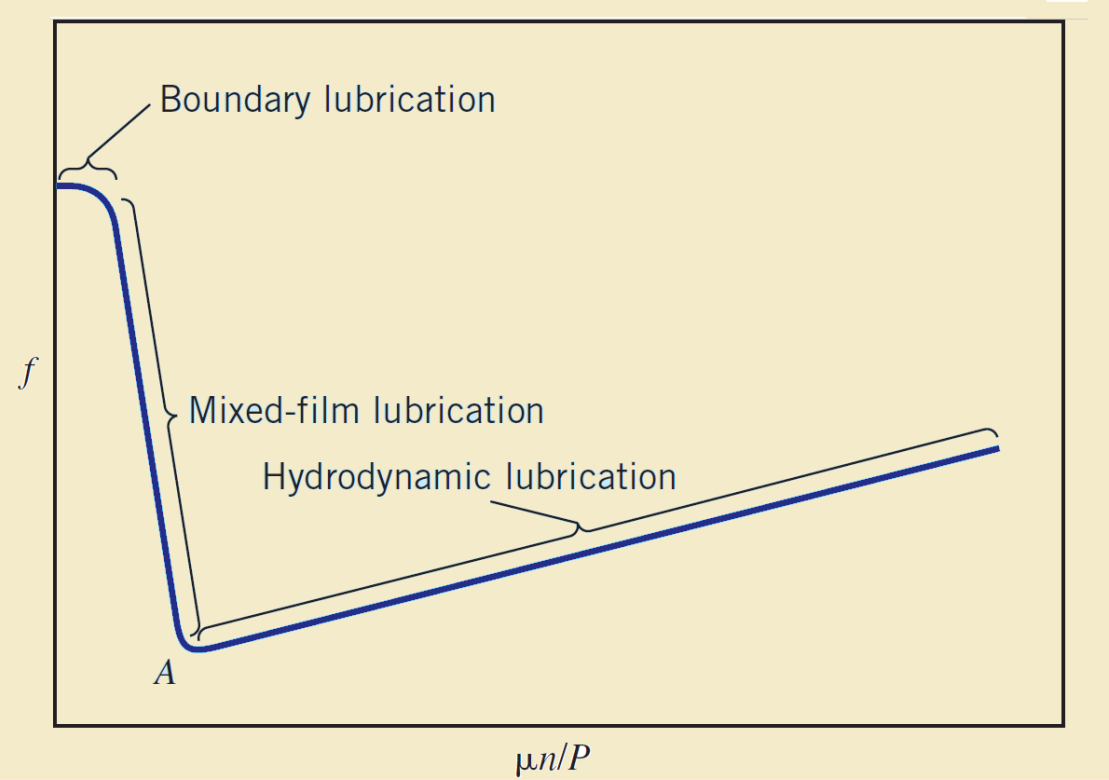
The objective of lubrication is to reduce friction wear and heating of machine parts that move relative to each other.

A Lubricant is a substance that when inserted between the moving surfaces, accomplishes theses purposes.

Type of lubrication means the extent to which the contacting surfaces are separated in a shaft bearing combination.

- Based on the type of lubrication, sliding contact bearings may be classified into the following categories:
  - (a) Thick film lubrication
  - (b) Thin film lubrication
  - (c) Boundary lubrication

- Based on the type of lubrication, sliding contact bearings may be classified into the following categories:
  - (a) Thick film lubrication
  - (b) Thin film lubrication
  - (c) Boundary lubrication



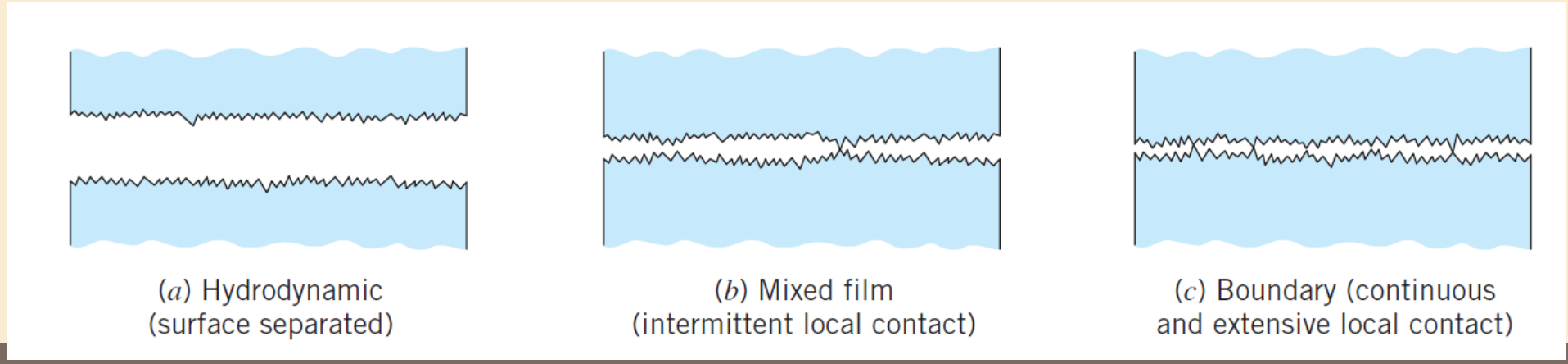
Types of lubricated Bearings

Thick film lubrication – the surfaces are separated by thick film of lubricant and there will not be any metal-to-metal contact. The film thickness is anywhere from 8 to 20 μm. Hydrodynamic lubrication.

Thin film lubrication – Here even though the surfaces are separated by thin film of lubricant, at some high spots Metal-to-metal contact does exist, it also known as mixed film lubrication. Surface

wear is mild. The coefficient of friction commonly ranges from 0.004 to 0.10.

Boundary lubrication – Here the surface contact is continuous and extensive. The lubricant is continuously smeared over the surfaces and provides a continuously renewed adsorbed surface film which reduces the friction and wear. The typical coefficient of friction is 0.05 to 0.20.



(*a*) Hydrodynamic (surface separated)

(*b*) Mixed film (intermittent local contact)

(*c*) Boundary (continuous and extensive local contact)

3. Classification based on Lubrication Mechanism

a. Hydrodynamic lubricated bearings:

   Separated by relatively thick film, no metal to metal contact, no external agency is required for pressure built up

b. Hydrostatic lubricated bearings :

   Lubricant is introduced at a pressure high enough to separate the surfaces

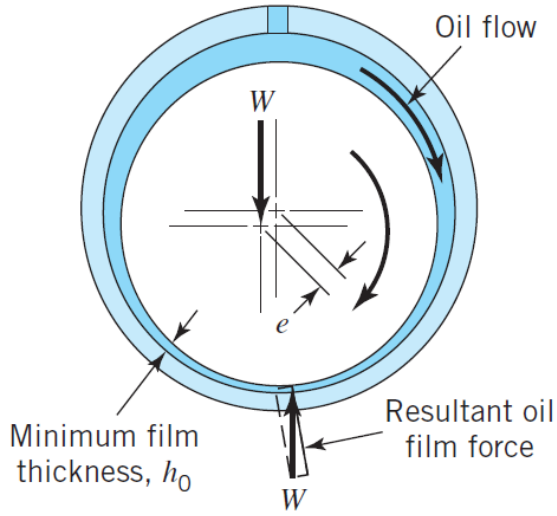
c. Elastohydrodynamic lubricated bearings

d. Boundary lubricated bearings

e. Solid film lubricated bearings

Hydrodynamic lubrication

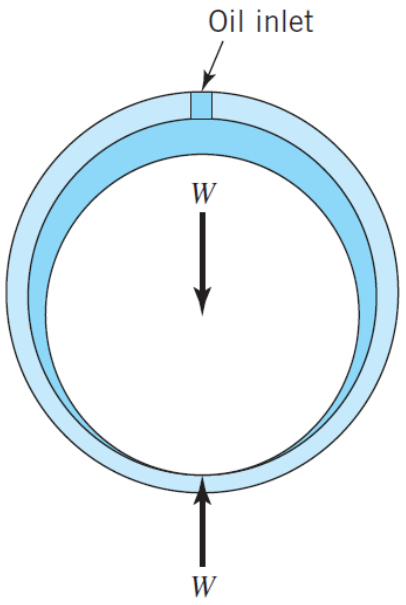
- Also called *full-film,* or *fluid lubrication has following characteristics:*
- The load-carrying surfaces of the bearing are separated by a thick film of lubricant.
- Requires an adequate supply of lubricant at all times.
- Does not require introduction of the lubricant under pressure.



Hydrodynamic Lubrication

Hydrodynamic lubrication

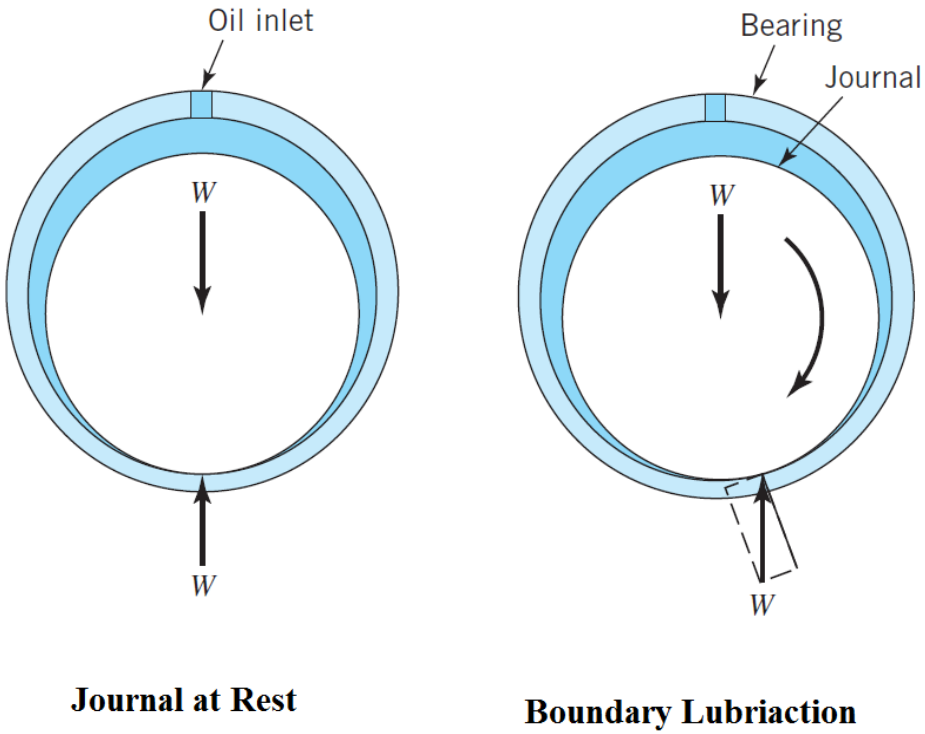
- Initially the loaded journal bearing is at rest.
- The bearing clearance space is filled with oil.
- The load (*W*) has squeezed out the oil film at the bottom.



Journal at Rest

Hydrodynamic lubrication

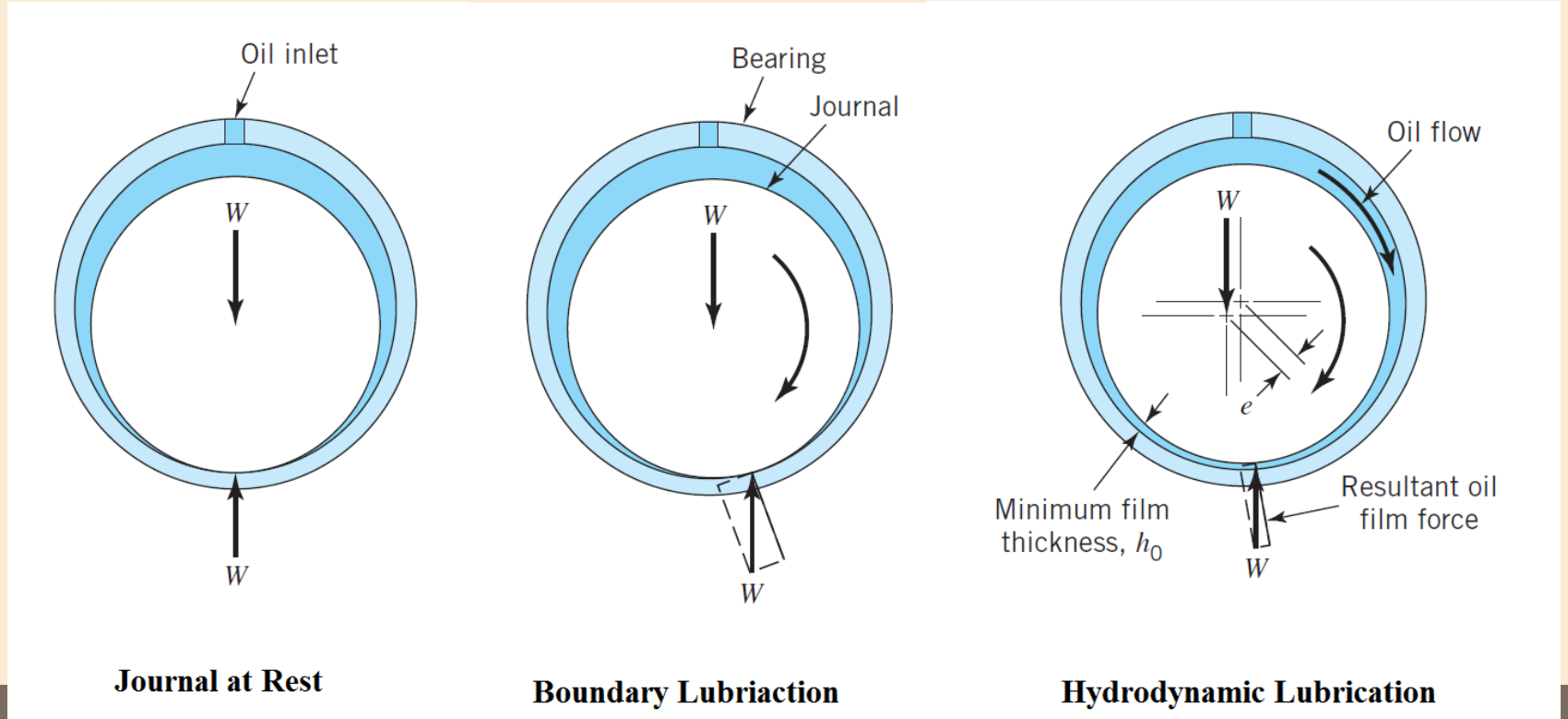
- The shaft starts Slow clockwise rotation.
- This will cause it to roll to the right position as it tries to “climb the wall” of the bearing surface. .
- Continuous *slow* rotation would cause the shaft to stay in this position.



The result is the boundary lubrication.

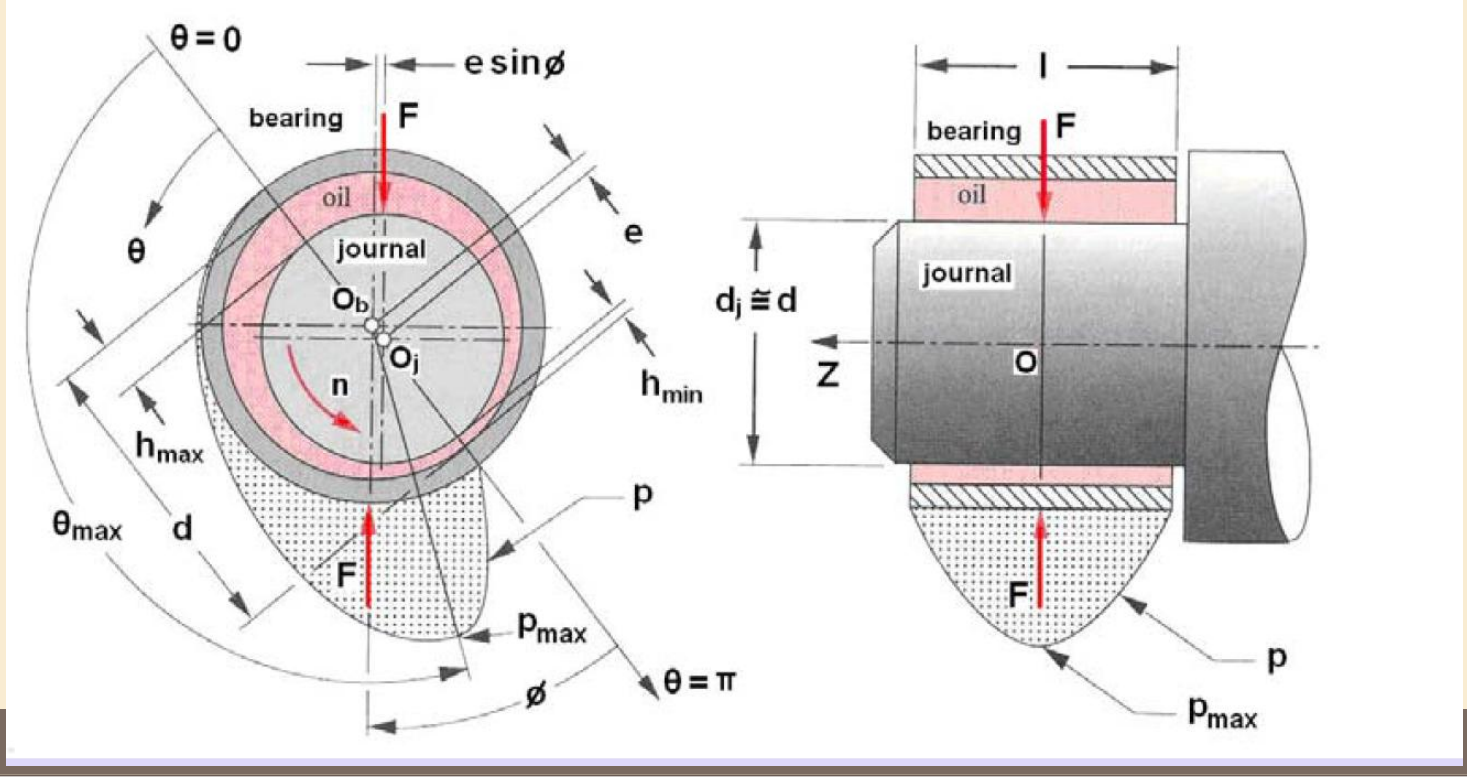
Hydrodynamic lubrication

- As the shaft rotating speed is increased, more and more oil goes into the contact zone.
- Finally a speed is reached at which the pressure built up in the contact zone is high enough to “float” the shaft.
- Under suitable conditions full separation of the journal and bearing surfaces occurs.



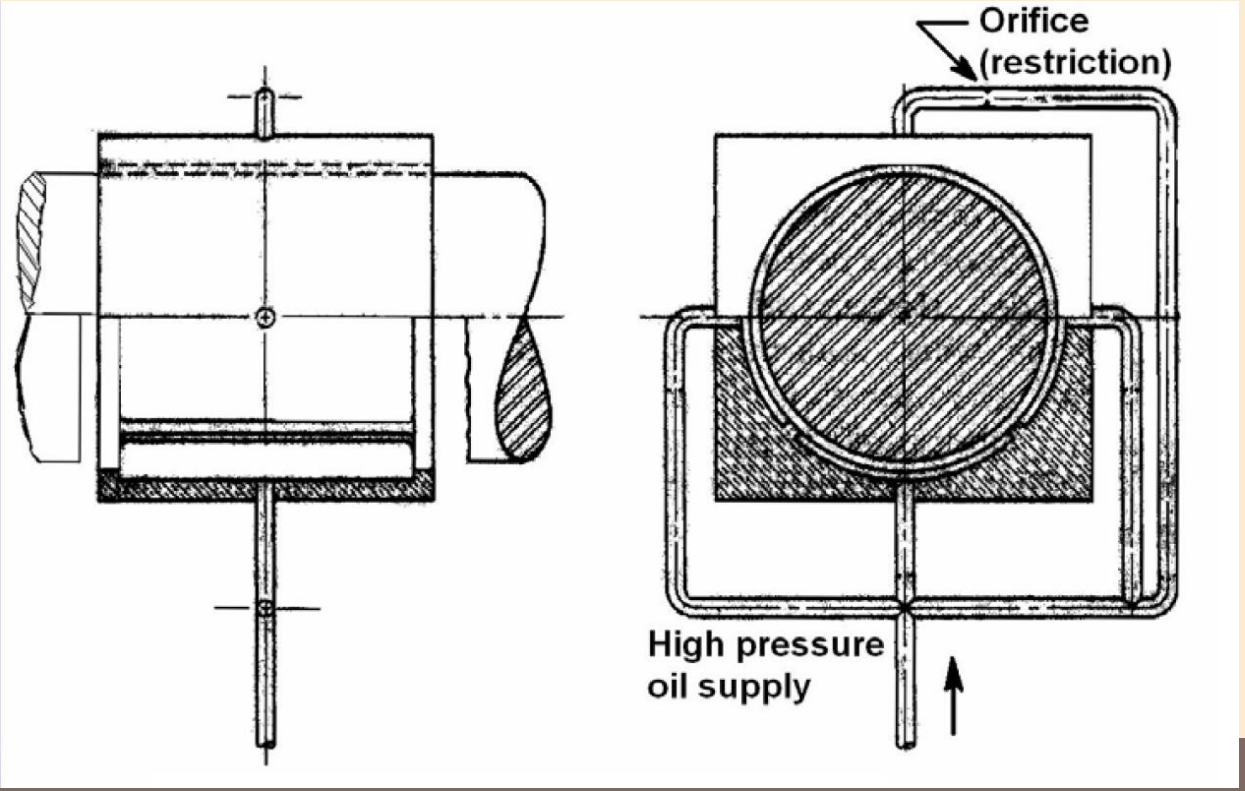
Hydrodynamic lubricated Bearings

- In these bearings the load-carrying surfaces are separated by a stable thick film of lubricant that prevents the metal-to-metal contact.
- The film pressure generated by moving surfaces that force the lubricant through a wedge shaped zone.
- At sufficiently high speed the pressure developed around the journal sustains the load.



Hydrostatic Lubrication

- In these bearings, externally pressurized lubricant is fed into the bearings to separate the surfaces with thick film of lubricant.
- These types of bearings do not require the motion of the surfaces to generate the lubricant film. Hence they can operate from very low speed to high speed.



Elastohydrodynamic Lubricated bearings.

- Rolling contact bearings come under this category. The oil film thickness is very small.
- The contact pressures are going to be very high. Hence to prevent the metal-to-metal contact, surface finishes are to be of high quality.
- Such a type of lubrication can be seen in
  - Gears,
  - Rolling contact bearings,
  - Cams etc.